Counts of seabirds around commercial fishing vessels within New Zealand waters

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Report prepared for the Department of Conservation

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To be cited as:
Yvan Richard, Edward R. Abraham & Katrin Berkenbusch (2011). Counts of seabirds around commercial fishing vessels within New Zealand waters. 30 pages. (Unpublished report held by the Department of Conservation, Wellington.)

EXECUTIVE SUMMARY

There are over 80 species of seabird breeding in New Zealand waters, but for many species their at-sea distribution remains largely unknown. This report presents a summary of seabird data in the New Zealand region, based on seabird counts made by fisheries observers on-board commercial fishing vessels between January 2004 and June 2009. During the 5.5-year period, there were 13 114 observations of seabirds around fishing vessels in New Zealand waters, from 442 fishing trips and 10 333 fishing events, resulting in 66 543 seabird counts.

The seabird counts were made in trawl, bottom-longline, surface-longline, set-net, and purse-seine fisheries, with the majority of observations in trawl fisheries. The spatial distribution of seabird counts observations corresponded with fishing effort, with observations in trawl fisheries widely distributed throughout continental shelf waters in New Zealand's Exclusive Economic Zone. Seabird count observations on bottom-longline vessels were concentrated on the Chatham Rise and in the Hauraki Gulf, and observations on surface-longline vessels were made in northeast and southwest New Zealand. For set-net and purse-seine fisheries, seabird count observations were in inshore waters, although the purse-seine fishery was represented by relatively few observations, which were restricted to northern North Island waters.

Seabird counts were made of sub-species, species, or species groups, depending on the level of identification. The recorded seabirds encompassed a wide range of species and species groups, from coastal taxa such as penguins, shags, gulls and terns to oceanic taxa such as albatrosses, petrels, and shearwaters. The most frequently recorded taxa were Cape petrels *Daption capense*, present in over 8000 observations, followed by New Zealand white-capped albatross *Thalassarche cauta steadi* and the species group giant petrels (*Macronectes* spp.), which were present in over 5000 observations. Southern Buller's albatross *Thalassarche bulleri bulleri*, the species group black-browed albatross (*Thalassarche melanophris* and *Thalassarche impavida*), white-chinned petrel *Procellaria aequinoctialis*, Salvin's albatross *Thalassarche salvini*, sooty shearwater *Puffinus griseus*, and great albatrosses (family Diomedeidae) were present in at least 3000 observations each. Other species and species groups were present considerably less often, being recorded during fewer than 200 observations.

The two most frequently recorded seabird species were also the most abundant, with Cape petrels and New Zealand white-capped albatross recorded at mean abundances of 63 and 33 individuals, respectively. Salvin's albatross were also common, reported at an average of 22 individuals in the observer counts. The species and species groups white-chinned petrel, sooty shearwater, southern Buller's albatross, albatrosses, and great albatrosses (*Diomedea* spp.) were each recorded with average abundances of at least 10 individuals per observation. All other species and species groups had low abundances, with an average of less than one individual recorded per observation. Recorded seabird counts were generally higher within a distance of 100-m from fishing vessels than at distances further away.

Seabird abundance around fishing vessels varied in relation to fishing method, with seabirds observed at considerably higher abundances around trawl vessels than in any other fishing method. The two seabird groups that consistently dominated abundance data across fisheries were albatrosses and petrels, although the albatrosses grouping was scarce or absent in set-net and purse-seine fisheries. In contrast, gulls and terns were only observed around set-net vessels. The observed abundance patterns are likely related to differences in the inshore-offshore distribution of the different seabird types and fisheries involved.

Regarding the spatial distribution of different seabird groups throughout New Zealand waters, small albatrosses (or mollymawks) *Thalassarche* spp. were the most dominant genus in seabird observations around fishing vessels, featuring frequently in inshore and offshore waters, including on Chatham Rise, north of Auckland Islands, and on New Zealand's west coast. Shearwaters *Puffinus* spp. dominated

observations in northeastern North Island, i.e., Hauraki Gulf, while *Procellaria* petrels were the dominant genus in observations from northern New Zealand, and in some records southeast of South Island and in subantarctic waters. Frequent records of giant petrels *Macronectes* spp. and great albatrosses *Diomedea* spp. were localised in southern waters and northwestern North Island, respectively, with prions *Pachyptila* spp. only dominating count data on the southern North Island west coast. Sea gull species within the genus *Larus* were only dominant in inshore records, interspersed across different North and South Island locations.

In view of the scarcity of information, observer records provide a valuable source of data regarding the distribution and abundance of seabirds in New Zealand waters. There are, however, limitations to these data, including different levels of observer skill and experience in the identification of seabird species, particularly for birds at a distance from the vessel and when similar-looking species are present. This limitation is partly alleviated through the use of species groupings and generic codes, but the identification of species at a lower taxonomic level also represents a loss of information. However, as these data are collected from fishing vessels, they are ideally suited for assessing the overlap between seabird species and fisheries. They account for both the distribution of the birds and how attracted they are to the fishing vessels, providing a measure of the interaction rate between seabirds and fisheries. This information is a key input to seabird risk assessments, and it is expected that these data will help to determine the risk that New Zealand fisheries pose to seabird populations.

1. INTRODUCTION

New Zealand is a global centre of seabird diversity (e.g., Karpouzi et al. 2007), with over 80 seabird species breeding in the New Zealand region (e.g., Taylor 2000a, 2000b). Many seabird species occurring in the New Zealand region, particularly albatrosses and petrels, are pelagic with a wide-ranging distribution, and population information relevant to their management and conservation is generally scarce. A number of studies have used remote tracking to collect data of the at-sea distribution of different seabird species, including in New Zealand waters (e.g., Robertson et al. 2003, Shaffer et al. 2006, Freeman et al. 2010, Torres et al. 2011). Although this technique provides accurate information, it requires the capture of seabirds at the breeding grounds to fit transmitters, and can only be used for species that are sufficiently large to carry transmitters. As a consequence, remote tracking data are limited to adult stages, and there is generally no information on the distribution of sub-adult birds. For species that have not been tracked, knowledge of their at-sea distribution remains limited to *ad hoc* observations and captures in fisheries.

Populations of many seabird species are declining world-wide, with a number of species globally threatened or endangered, i.e., albatrosses and petrels (Croxall & Gales 1998, BirdLife International 2004, International Union for Conservation of Nature (IUCN) 2010). A critical source of mortality is the incidental capture of seabirds in commercial fisheries, such as long lining and trawling (Weimerskirch et al. 2000, Anderson et al. 2011). Recognition of the threat posed by fisheries has prompted an increase in management and conservation efforts to reduce seabird bycatch (e.g., Melvin et al. 2006, Sullivan et al. 2006, Bull 2007). In New Zealand, assessment of seabird bycatch involves the systematic recording of at-sea mortality data, and statistical modelling to derive total estimates of seabird captures (Abraham & Thompson 2010, 2011). Estimation of total bycatch requires an extrapolation from observed fishing to all fishing, and would be improved if accurate knowledge of the distribution and abundance of seabirds around fishing vessels was available; however, these data are generally scarce (but see Petersen et al. 2008, Jiménez et al. 2011, Torres et al. 2011).

The most comprehensive reference on seabird distribution in New Zealand waters currently available is the National Aquatic Biodiversity Information System (NABIS), provided by the Ministry for Primary Industries (http://www.nabis.govt.nz). This database includes distribution maps of seabirds around New Zealand, hand-drawn by expert scientists by integrating different sources of information, including published scientific articles and unpublished reports. A key source of data was the Seabirds At Sea database, held by the Museum of New Zealand Te Papa Tongarewa. Although the maps provide general information on the distribution of seabirds, they are not derived from detailed systematic analysis, but represent a collation of information from a variety of sources.

Some seabird species are particularly attracted to fishing vessels because of the fishing waste discarded, the bait used, or the large quantity of fish surfacing during hauling (e.g., Cherel et al. 1996, Weimerskirch et al. 2000, Pierre et al. 2010). The interactions between seabirds and fishing vessels vary between species, and the seabird count data reflect both the overlap in the distribution of fishing effort and seabird populations, and the attraction of the seabirds to the fishing. This makes the seabird count data a suitable for assessing the risk that fishing operations pose to seabird populations (Richard et al. 2011).

The current study presents data on the distribution and abundance of seabirds observed around commercial fishing vessels in New Zealand waters. Data were collected by government fisheries observers on-board fishing vessels between January 2004 and June 2009. This report is intended as a preliminary analysis of the data, documenting the data grooming that has been carried out to date, and illustrating some of the characteristics of the dataset. The seabird count data are a rich source of information on interactions between seabirds and fishing vessels. The data are being made publicly available so that a more thorough analysis may be undertaken by anyone with an interest in this area.

2. METHODS

2.1 Data collection

In New Zealand waters, Ministry for Primary Industries observers are present on a selected commercial fishing trips. Their primary role is to collect information that is relevant to the operation of the quota management system, including catch effort and bycatch data. Since 2004, observers have also collected seabird abundance data for the Department of Conservation as part of the Conservation Services Programme (CSP). For the seabird abundance observations, they record the number of seabirds observed in the proximity of fishing vessels. Seabird counts are recorded for each identifiable species or species group, using a unique 3-letter code (Table 1). These bird count observations are generally made during the first fishing event of the day, and sometimes more frequently depending on the other duties of the observer.

During each observation, counts were conducted separately for each seabird species or species group that was distinguished by the observer. Each recorded observation consisted of a number of counts (for each of the species or species groups identified).

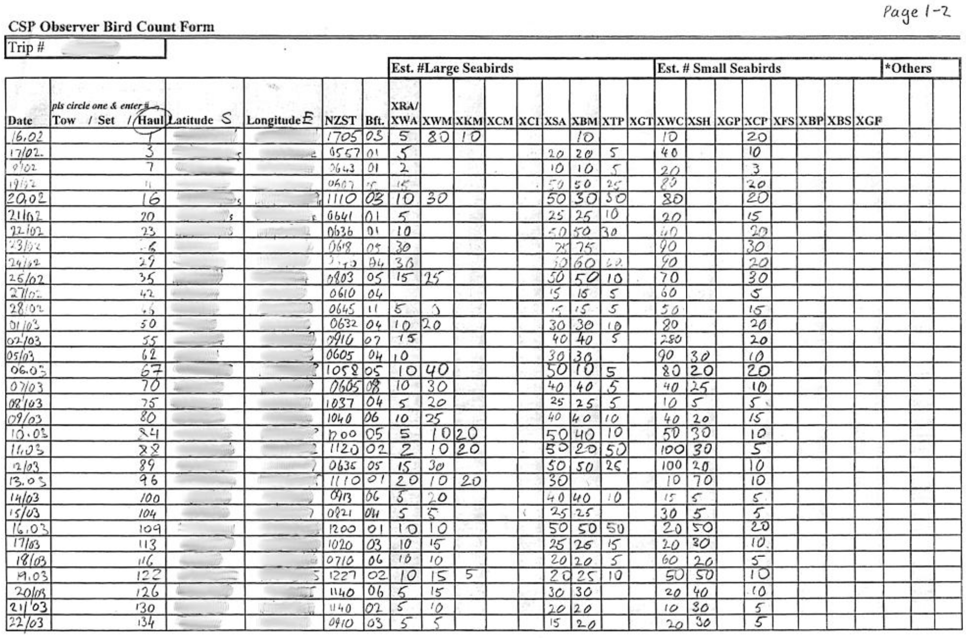
In trawl fisheries, counts were conducted during daylight hauls, with a haul defined as the time between the trawl doors surfacing and the net hitting the stern ramp or being lifted from the water. In longline fisheries, counts were undertaken during observations of every daylight set and haul, at the start, middle, and end of setting and hauling, whenever possible. In set-net fisheries, counts were conducted during observations of the setting of the net, with subsequent counts during hauling, starting at the beginning of the haul and then repeated every 30 minutes; the final observation was at the end of hauling if at least 15 minutes had passed since the last count.

Initially, estimates of seabird abundance were recorded as notes in observer diaries and on longlining forms, before specific forms were introduced in 2006 (see example in Figure 1). On the first version of these forms, seabird counts were recorded for each observation (in a single row) by species or species code, with pre-printed codes for those species that were most likely to be encountered. On this form, counts of all wandering and royal albatrosses were grouped together. Also recorded were the trip number, date, position (latitude, longitude), time, and type of fishing event (tow, set, or haul), and the sea state (Beaufort scale) for each observation.

Since 1 October 2007 (the start of the 2007–08 fishing year), an updated version of the form has been used that includes a distance category for seabird counts (see example in Figure 2). Observers were asked to specify the number of seabirds within and beyond 100 m distance from the vessel. Owing to the introduction of the distance category, a single observation may have two counts of a species or species group recorded on the form, with separate counts for each distance category. Some observations may include counts of birds close to the vessel, without explicitly stating that there were no birds further away during the observation. Another modification of the updated form was that codes of species most likely to be encountered were no longer pre-printed, allowing the observer to record all the bird taxa that were present, with as detailed an identification as they were able to make.. In addition, information on the position of the fishing event was no longer requested, as the latitude and longitude associated with seabird counts were obtained from observer- and fisher-reported fishing effort forms, based on the corresponding trip and fishing event numbers.

Table 1: Codes used to describe species or species groups for observer counts of seabirds in the proximity of commercial fishing vessels between January 2004 and June 2009. The 4-letter codes were created for this project to accommodate the observers' comments when no code existed.

Code	Common name	Scientific name
CAAN	Southern skua	*Catharacta antarctica*
CYAT	Black swan	*Cygnus atratus*
PTMO	Soft-plumaged petrel	*Pterodroma mollis*
PTNE	Kermadec petrel	*Pterodroma neglecta*
PUAS	Little shearwater	*Puffinus assimilis*
SKUA	Skuas	*Catharacta* spp. & *Stercorarius* spp.
SOOT	Sooty albatrosses	*Phoebetria* spp.
STPA	Arctic skua	*Stercorarius parasiticus*
THCA	White-capped albatrosses	*Thalassarche cauta*
TUPH	Song thrush	*Turdus philomelos*
XAF	Antarctic fulmar	*Fulmarus glacialoides*
XAL	Albatrosses	Diomedeidae
XAN	Antipodean albatross	*Diomedea antipodensis antipodensis*
XAP	Antarctic petrel	*Thalassoica antarctica*
XAS	Wandering albatross	*Diomedea exulans*
XBG	Southern black-backed gull	*Larus dominicanus dominicanus*
XBM	Southern Buller's albatross	*Thalassarche bulleri bulleri*
XBP	Black petrel	*Procellaria parkinsoni*
XBS	Buller's shearwater	*Puffinus bulleri*
XCA	Snares Cape petrel	*Daption capense australe*
XCC	Cape petrel	*Daption capense capense*
XCI	Chatham Island albatross	*Thalassarche eremita*
XCM	Campbell black-browed albatross	*Thalassarche impavida*
XCP	Cape petrels	*Daption capense*
XDP	Common diving petrel	*Pelecanoides urinatrix*
XFL	Fluttering shearwater	*Puffinus gavia*
XFP	Fairy prion	*Pachyptila turtur*
XFS	Flesh-footed shearwater	*Puffinus carneipes*
XFT	Black-bellied storm petrel	*Fregetta tropica*
XGA	Great albatrosses	*Diomedea* spp.
XGB	Grey-backed storm petrel	*Garrodia nereis*
XGF	Grey-faced petrel	*Pterodroma macroptera gouldi*
XGM	Grey-headed albatross	*Thalassarche chrysostoma*
XGP	Grey petrel	*Procellaria cinerea*
XGT	Australasian gannet	*Morus serrator*
XHG	Shags	Phalacrocoracidae
XIY	Indian Ocean yellow-nosed albatross	*Thalassarche carteri*
XKM	Black-browed albatrosses	*Thalassarche melanophris* & *T. impavida*
XLA	Gulls and terns	Laridae & Sternidae
XLB	Little penguin	*Eudyptula minor*
XLM	Light-mantled sooty albatross	*Phoebetria palpebrata*
XMA	Smaller albatrosses	*Thalassarche* spp.
XMP	Mottled petrel	*Pterodroma inexpectata*
XNB	Northern Buller's albatross	*Thalassarche bulleri platei*
XNP	Northern giant petrel	*Macronectes halli*
XNR	Northern royal albatross	*Diomedea sanfordi*
XPB	Southern and northern Buller's albatrosses	*Thalassarche bulleri*
XPC	*Procellaria* petrels	*Procellaria* spp.
XPE	Petrels	Procellariidae
XPG	Penguins	Spheniscidae
XPH	Hutton's shearwater	*Puffinus huttoni*
XPM	Mid-sized petrels & shearwaters	*Pterodroma, Procellaria* & *Puffinus* spp.
XPN	Prions	*Pachyptila* spp.
XPP	Spotted shag	*Phalacrocorax punctatus*
XPS	Pied shag	*Phalacrocorax varius varius*
XRA	Southern royal albatross	*Diomedea epomophora*
XRB	Red-billed gull	*Larus novaehollandiae scopulinus*
XSA	Salvin's albatross	*Thalassarche salvini*
XSB	Seabird	-
XSG	Seagulls	*Larus* spp.
XSH	Sooty shearwater	*Puffinus griseus*
XSL	Seabird - large	-
XSM	Southern black-browed albatross	*Thalassarche melanophris*
XSP	Southern giant petrel	*Macronectes giganteus*
XSR	White-fronted tern	*Sterna striata*
XSS	Seabird - small	-
XST	Storm petrels	Hydrobatidae
XSU	Boobies and gannets	Sulidae
XSW	Shearwaters	*Puffinus* spp.
XSY	Tasmanian albatross	*Thalassarche cauta cauta*
XTE	Terns	Sternidae
XTP	Giant petrels	*Macronectes* spp.
XTS	Short-tailed shearwater	*Puffinus tenuirostris*
XWA	Wandering albatrosses	*Diomedea exulans* & *D. antipodensis*
XWC	White-chinned petrel	*Procellaria aequinoctialis*
XWF	White-faced storm petrels	*Pelagodroma* spp.
XWH	White-headed petrel	*Pterodroma lessonii*
XWM	New Zealand white-capped albatross	*Thalassarche cauta steadi*
XWP	Westland petrel	*Procellaria westlandica*
XXP	Petrels, prions and shearwaters	Hydrobatidae, Procellariidae & Pelecanoididae



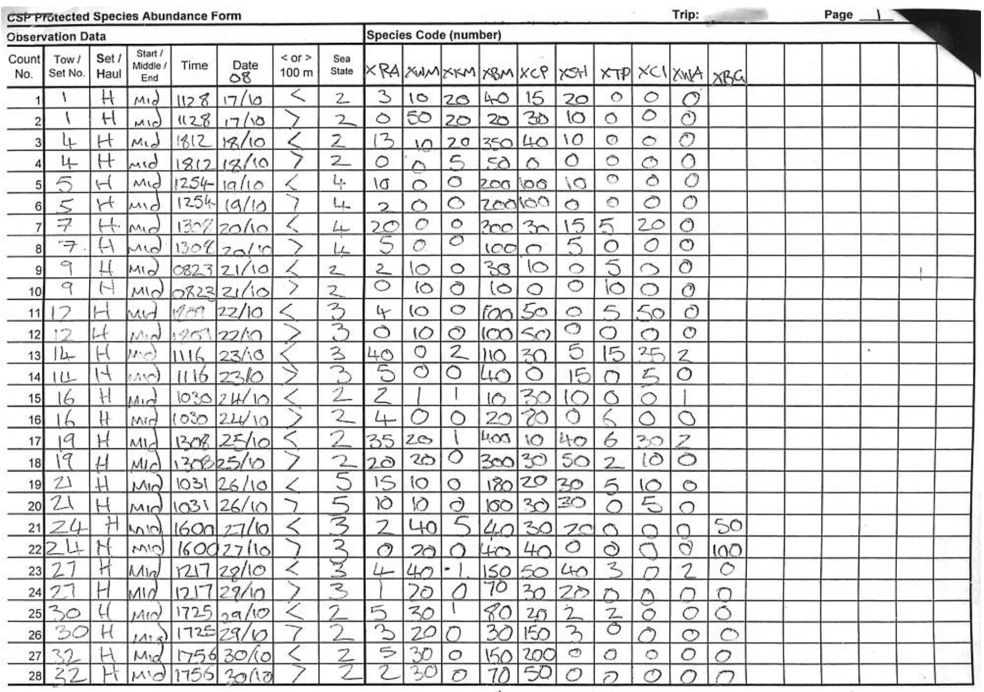
CSP Observer Bird Count Form

Page 1-2

Trip # [redacted]

Date	pls circle one & enter # Tow / Set / (Haul)	Latitude S	Longitude E	NZST	Bft.	XRA/ XWA	XWM	XKM	XCM	XCI	XSA	XBM	XTP	XGT	XWC	XSH	XGP	XCP	XFS	XBP	XBS	XGF	*Others
						Est. #Large Seabirds									Est. # Small Seabirds								
16.02	1	[redacted]	[redacted]	1705	03	5	80	10				10			10			20					
17/02.	3	[redacted]	[redacted]	0557	01	5					20	20	5		40			10					
18/02	7	[redacted]	[redacted]	0643	01	2					10	10	5		20			3					
19/02	11	[redacted]	[redacted]	0607	05	15					50	50	25		80			20					
20.02	16	[redacted]	[redacted]	1110	03	10	30				50	30	30		80			20					
21/02	20	[redacted]	[redacted]	0641	01	5					25	25	10		20			15					
22/02	23	[redacted]	[redacted]	0636	01	10					50	50	30		60			20					
23/02	26	[redacted]	[redacted]	0618	05	30					75	75			90			30					
24/02	29	[redacted]	[redacted]	[illegible]	04	30					60	60	60		90			20					
26/02	35	[redacted]	[redacted]	0803	05	15	25				50	50	10		70			30					
27/02	42	[redacted]	[redacted]	0610	04						15	15	5		60			5					
28/02	46	[redacted]	[redacted]	0645	11	5	5				15	15	5		50			15					
01/03	50	[redacted]	[redacted]	0632	04	10	20				30	30	10		80			20					
02/03	55	[redacted]	[redacted]	0910	07	15					40	40	5		280			20					
05/03	62	[redacted]	[redacted]	0605	04	10					30	30			90	30		10					
06.03	67	[redacted]	[redacted]	1058	05	10	40				50	10	5		80	20		20					
07/03	70	[redacted]	[redacted]	0605	08	10	30				40	40	5		40	25		10					
08/03	75	[redacted]	[redacted]	1037	04	5	20				25	25	5		10	5		5					
09/03	80	[redacted]	[redacted]	1040	06	10	25				40	40	10		40	20		15					
10.03	84	[redacted]	[redacted]	1200	05	5	10	20			50	40	10		50	30		10					
11.03	88	[redacted]	[redacted]	1120	02	2	10	20			50	20	50		100	30		5					
12/03	89	[redacted]	[redacted]	0635	05	15	30				50	50	25		100	20		10					
13.03	96	[redacted]	[redacted]	1110	01	20	10	20			30				10	70		10					
14/03	100	[redacted]	[redacted]	0913	06	5	20				40	40	10		15	5		5					
15/03	104	[redacted]	[redacted]	0821	04	5	5				25	25			30	5		5					
16.03	109	[redacted]	[redacted]	1200	01	10	10				50	50	50		20	50		20					
17/03	113	[redacted]	[redacted]	1020	03	10	15				25	25	15		20	30		10					
18/03	116	[redacted]	[redacted]	0710	06	10	10				20	20	5		60	20		5					
19.03	122	[redacted]	[redacted]	1227	02	10	15	5			20	25	10		50	50		10					
20/03	126	[redacted]	[redacted]	1140	06	5	15				30	30			20	40		10					
21/03	130	[redacted]	[redacted]	1140	02	5	10				20	20			10	30		5					
22/03	134	[redacted]	[redacted]	0910	03	5	5				15	20			20	30		5					

Figure 1: Example of a paper form used by observers until 2007 to record counts of seabirds in the proximity of fishing vessels. (The trip number and coordinates of fishing events are obscured for confidentiality.)



CSP Protected Species Abundance Form

Trip: [redacted] Page 1

Count No.	Tow / Set No.	Set / Haul	Start / Middle / End	Time	Date 08	< or > 100 m	Sea State	XRA	XWM	XKM	XBM	XCP	XSH	XTP	XCI	XWA	XBG
Observation Data								Species Code (number)									
1	1	H	Mid	1128	17/10	<	2	3	10	20	40	15	20	0	0	0	
2	1	H	Mid	1128	17/10	>	2	0	50	20	20	30	10	0	0	0	
3	4	H	Mid	1812	18/10	<	2	13	10	20	350	40	10	0	0	0	
4	4	H	mid	1812	18/10	>	2	0	0	5	50	0	0	0	0	0	
5	5	H	Mid	1254	19/10	<	4	10	0	0	200	100	10	0	0	0	
6	5	H	mid	1254	19/10	>	4	2	0	0	200	100	0	0	0	0	
7	7	H	Mid	1308	20/10	<	4	20	0	0	300	30	15	5	20	0	
8	7	H	Mid	1308	20/10	>	4	5	0	0	100	0	5	0	0	0	
9	9	H	Mid	0823	21/10	<	2	2	10	0	30	10	0	5	0	0	
10	9	H	Mid	0823	21/10	>	2	0	10	0	10	0	0	10	0	0	
11	12	H	Mid	1209	22/10	<	3	4	10	0	100	50	0	5	50	0	
12	12	H	Mid	1209	22/10	>	3	0	10	0	100	50	0	0	0	0	
13	14	H	Mid	1116	23/10	<	3	40	0	2	110	30	5	15	35	2	
14	14	H	Mid	1116	23/10	>	3	5	0	0	40	0	15	0	5	0	
15	16	H	Mid	1030	24/10	<	2	2	1	1	10	30	10	0	0	1	
16	16	H	Mid	1030	24/10	>	2	4	0	0	20	20	0	6	0	0	
17	19	H	Mid	1308	25/10	<	2	35	20	1	400	10	40	6	30	2	
18	19	H	Mid	1308	25/10	>	2	20	20	0	300	30	50	2	10	0	
19	21	H	Mid	1031	26/10	<	5	15	10	0	180	20	30	5	10	0	
20	21	H	Mid	1031	26/10	>	5	10	10	0	100	30	30	0	5	0	
21	24	H	Mid	1600	27/10	<	3	2	40	5	40	30	20	0	0	0	50
22	24	H	Mid	1600	27/10	>	3	0	20	0	40	40	0	0	0	0	100
23	27	H	Mid	1217	28/10	<	3	4	40	1	150	50	40	3	0	2	0
24	27	H	Mid	1217	28/10	>	3	1	20	0	70	30	20	0	0	0	0
25	30	H	Mid	1725	29/10	<	2	5	30	1	80	20	2	2	0	0	0
26	30	H	Mid	1725	29/10	>	2	3	20	0	30	150	3	0	0	0	0
27	32	H	Mid	1756	30/10	<	2	5	30	0	150	200	0	0	0	0	0
28	32	H	Mid	1756	30/10	>	2	2	30	0	70	50	0	0	0	0	0

Figure 2: Example of a paper form used by observers since 2007 to record counts of seabirds in the proximity of fishing vessels. (The trip number is obscured for confidentiality.)

2.2 Data processing

Observer data recorded on paper forms between January 2004 and June 2009 were double-entered into a database, with discrepancies between entries reconciled using the original forms. Records made in observer diaries were not included in the analysis, as the interpretation of these data required a high level of subjectivity. All entered data were subsequently groomed to correct for errors and mismatches in the original forms (see Table 2 for a complete summary of corrections, including the number of observations concerned). Particular attention was given to the species and species group codes, the associated seabird counts, the date and time of the observations, their geographical position, and the distance at which seabirds were observed (either within or beyond 100 m of the vessel).

Table 2: Summary of amendments to seabird observation records made during data grooming, including the number of records changed.

Action	Field	Reason	Changes
Update	Code	Obsolete code XMM replaced with proper XMA	173
Delete	-	Records in notebooks are unreliable	18011
Delete	-	Nonsensical trips	78
Delete	-	Nonsensical events	124
Delete	-	Non-standard form	21
Update	Fishing_event	Typo in event number	22
Update	Date	Typo in year	39
Update	Fishing_event	Fishing event number modified to match observer effort data	666
Delete	-	Nonsensical record	96
Delete	-	Anecdotal observation of marine mammal	128
Update	Code	Counts written in empty column, put back in right column	3
Update	Code	Corrected species code	6
Update	Code	Converted species name to code	231
Update	Code	Several codes recorded; took common parent.	4461
Update	Code	Took most generic code among several recorded codes.	309
Update	Code	Took common parent, which was among several codes recorded.	40
Delete	-	Counts with nonexistent or non-bird codes	553
Update	Dist_threshold	Distance threshold reported explicitly in distance field	161
Delete	-	Poor visibility, as noted by the observer	91
Update	Distance	Manually corrected distance field	18
Update	Distance	Inverted distance symbol manually	881
Update	Observer	Non-specific observer name	41
Update	Event_type	Standardised event type code	6
Update	Time	Missing time taken from observer reported effort database	151
Update	Date	Corrected date manually	196
Update	Date	Took date from observer reported effort	35096
Update	Date	Corrected year based on fisher reported effort data	90
Update	Date	Corrected year manually	52
Update	Date	Took date from OTR by making up a regular date sequence between start and end of trip	724
Update	Latitude	Took lat/long from bird count forms instead of observer reported effort database	971
Update	Longitude	Took lat/long from bird count forms instead of observer reported effort database	971
Update	Latitude	Took lat/long from fisher reported effort database	31
Update	Longitude	Took lat/long from fisher reported effort database	31
Update	Latitude	Imputed lat/long from previous and next event if possible	14
Update	Longitude	Imputed lat/long from previous and next event if possible	14
Delete	-	Observation outside NZ EEZ	241
Update	Latitude	Observation on land	139
Update	Longitude	Observation on land	139
Update	Abundance	Bird count written as range. Took rounded mean of bounds	31
Update	Wind_speed	Wind speed written as range. Took rounded mean of bounds	5

Three-letter codes are assigned to all species observed caught in commercial fisheries in New Zealand waters, involving either "specific" or "generic" codes based on the level of identification. Specific codes are used for identifications at the subspecies or species level, whereas a generic code is applied when groups of similar species cannot be distinguished at the species-level. Amendments made during data grooming included corrections to the species and species group codes, and assigning a code when a species name instead of a code was used on the form (see Table 3 for a summary of code assignments). On some seabird abundance forms, count data were recorded for bird species for which there are no official codes, such as little shearwater and arctic skua. For these records, a 4-letter code was created for this study. Any unknown seabird codes (starting with the letter "X", the first letter of all seabird codes) were assigned the generic seabird code XSB.

Some count data had more than one code assigned on the form, owing to observer uncertainty of the species' identification, or the combined grouping of wandering and royal albatrosses on the earlier form. For these records, the codes for the closest common ancestor in the code hierarchy tree was used (Figure 3). For example, a count recorded as 'XRA/XWA' (either royal or wandering albatross), would be assigned the code 'XGA' (great albatross). Table 4 summarises the code assignments when more than one code was used by observers. Data were excluded when the species code or name was missing or a code could not be unambiguously assigned. From time to time, observers also recorded the presence of other animals (mostly marine mammals). The current dataset was restricted to seabirds only.

For consistency, the common names and the taxonomy used in this project followed the recommendations of the Ornithological Society of New Zealand checklist committee (2010).

Abundance data included counts that were recorded as ranges. For these data, the mid-point value was used in the analysis. The maximum recorded count was 15 000 Salvin's albatrosses at a single fishing event, during a trawl targeting hoki *Macruronus novaezelandiae*. Although this value seemed implausibly high, it was retained in the dataset with other high seabird counts recorded by the observer during the same trip.

Missing dates, times, and geographical positions were obtained by linking seabird count data to observer-reported and fisher-reported effort data using trip and fishing event (tow or set) numbers. The effort data was obtained from the Ministry for Primary Industries *warehou* and COD databases. On some abundance forms, observers started with the first event they observed and the sequence of event numbers followed their observations, instead of following the numbering on the fishing effort forms. The mismatches between count and effort data forms were reconciled using the trip number and the date and time of the fishing events. Where possible, the dates and times were also deduced from the observer-reported fishing effort forms based on the trip and fishing event numbers. When these data were also missing, they were obtained from the Observer Trip Record (OTR) table of the COD database, which independently stores information about the assignment of observers to fishing trips, and details of each fishing trip. As the OTR records only contain the start and end dates of the period of time observers were on board a vessel, the date of each fishing event was calculated by assuming that the observed fishing events were evenly distributed throughout the period of time observers were on the vessel.

Trip and fishing event numbers were also used to assign a geographical position (latitude and longitude) to each observation. Preference was given to coordinates noted on observer-reported fishing effort forms. When there was no observer effort form, or fishing events on the seabird count and observer-effort could not be linked, latitude and longitude were used from the seabird count forms. When latitude and longitude were not recorded on count forms, the coordinates on fisher-reported effort forms were used. For some observations, there were no coordinates available, although they were recorded for other fishing events on the same trip. Latitude and longitude for those few observations were calculated taking the mid point between the previous and the next locations. Some coordinates indicated fishing locations on land, and these coordinates were removed, although the count record was kept in the dataset. Observations occurring outside New Zealand's Exclusive Economic Zone (EEZ) were excluded. Typographical errors in the date or fishing event number were corrected when possible, e.g., by comparing information on count forms with that on other forms from the same trip.

Since the 2007–08 fishing year, observers have been requested to distinguish between counts of seabirds within and beyond 100 m of the vessel. On some forms, this distance information was inconsistently reported as different cut-off points were applied to the count data (e.g., 50 or 60 m). These data were

Table 3: Assignment of codes to seabird observation records, including the number of records concerned. A 4-letter code was created when no 3-letter code existed. Comments are presented verbatim from the observer forms.

Comment	Code	Number of counts
XTP giant	XTP	23
XSI	XSB	20
XSK XXP	XSB	18
XPA	XSB	15
Brown skua	CAAN	14
Soft plumage petrel	PTMO	9
XBP XUP	XBP	7
XGP grey	XGP	6
Petrel	XPE	6
Arctic skua	STPA	6
XKW	XSB	5
XBU	XSB	5
Terns	XTE	5
White ronted tern	XSR	4
XSF	XSB	4
XWC white	XWC	4
Prions	XPN	4
XBC	XSB	4
Red billed gull XLA	XRB	4
Gannet	XGT	4
XW2	XSB	4
Shag	XHG	3
XGH	XSB	3
Storm	XST	3
Huttons swater	XPH	3
Tern XLA	XTE	3
Ganet	XGT	3
XBN	XSB	2
Antarctic fulmar	XAF	2
Thrush	TUPH	2
XKY	XSB	2
XBE	XSB	2
Prion	XPN	2
Kelp gull	XBG	2
Huttons shearwater	XPH	2
White fronted tern	XSR	2
Soo alb	SOOT	2
XIW	XSB	2
Shear water	XSW	2
XRM	XSB	2
Little shearwaters	PUAS	1
XBG black	XBG	1
XBM bulle	XBM	1
XNC	XSB	1
XSK	XSB	1
Black	XSB	1
Little	XSB	1
Black swan	CYAT	1
Blue penguin	XLB	1
Red bill gull	XRB	1
Kelp bulls	XBG	1
Tern	XTE	1
Whitef tern	XSR	1
Little shearwater	PUAS	1
Red billed gull	XRB	1
Ker. petrel	PTNE	1

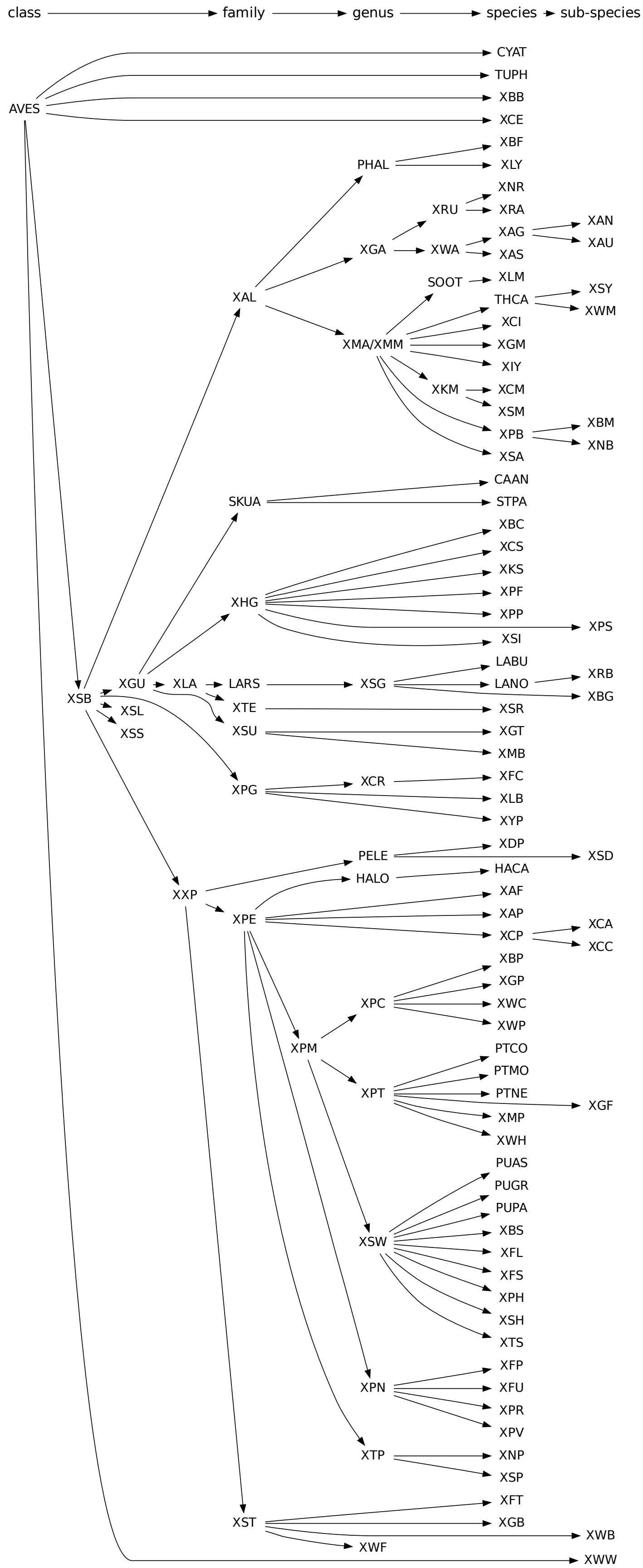


Figure 3: Hierarchy of codes used to define the species or species groups during the bird counts. This hierarchy was used when processing the data to resolve conflicts when two or more codes were used by the observers to define a species or species group. (See Table 1 for the species and species groups defined by each code.)

Table 4: Assignment of a single species code to observer records with multiple codes that describe a species or species group observed during counts of seabirds in the proximity of commercial fishing vessels. The number of affected counts is also presented. (See Table 1 for the associated species or species grouping of each code.)

From observers	Species interpretation	Counts
XRA/XWA	XGA	4165
XCM/XKM	XKM	128
XCI/XSA	XMA	73
XPE/XSH	XPE	65
XSA/XSY	XMA	47
XAL/XRA/XWA	XAL	40
XWC/XWP	XPC	39
XSY/XWM	THCA	31
XNP/XSP	XTP	25
XWC/XXP	XXP	25
XFS/XPE	XPE	24
XSB/XSI	XSB	20
XBP/XPE	XPE	20
XSB/XXP	XSB	18
XKM/XSA	XMA	17
XBP/XWC	XPC	14
XSH/XWC	XPM	13
XBP/XWP	XPC	13
XSA/XWM	XMA	6
XCM/XGM	XMA	6
XPE/XWP	XPE	5
XFS/XSH	XSW	4
XBC/XSB	XSB	4
XBG/XFS	XSB	2
XBM/XKM/XSY	XMA	2
XBP/XFS	XPM	1
XSA/XWH	XSB	1
XKM/XWM	XMA	1
XCI/XWP	XSB	1

only included if they were unambiguous. When observers misinterpreted the "<" and ">" signs but clearly defined the categories in words (e.g., "more", "less"), data were included. Some inconsistencies in the distance fields could also be corrected because observers had systematically used specific codes for seabirds close to the vessel and generic ones for seabirds further away for the corresponding records, and these data were also included, after correcting the distance information.

Some observations involved counts that were conducted during poor visibility caused by fog or low light levels. When these conditions were recorded, observations were removed to keep data comparable. Wind speed was measured on the Beaufort scale and on some forms noted as a range. For the observations concerned, the midpoint was taken.

3. RESULTS

3.1 Data summary - observations

The final dataset for the period between January 2004 and June 2009 consisted of 13 114 observations, involving 442 fishing trips and 10 333 fishing events. During these observations, 66 543 bird counts were recorded, at the species or species group level, close to or distant from the vessel. Three counts involved species other than seabirds, with two counts of song thrush and one count of black swan.

There were few seabird count observations in 2004 and 2005 (Table 5, Figure 4). Since then, the number of observations has steadily increased, with over 4000 observations conducted in 2008, and over 1500 observations in the first half of 2009. Across all years, there was relatively little variation in the number of observations per month, although there was a marked peak in the number of observations in November. The majority of observations were made during the morning, reflecting a preference by CSP for the observers to conduct the counts during the first fishing event of the day.

Observations in the first two years were predominantly in bottom-longline fisheries, with a small proportion in trawl fisheries (Table 5). Since 2006, there has been an increase in the number of observations and a greater spread across different fisheries. Over the entire study period, the majority of observations were in trawl fisheries, followed by bottom-longline, set-net, surface-longline, and purse-seine fisheries. The number of observations conducted in the latter fishery was considerably lower than in any other fishery, with a total of 180 observations conducted during purse-seining operations. There was no obvious seasonal trend in the number of observations by fishery. (Figure 5).

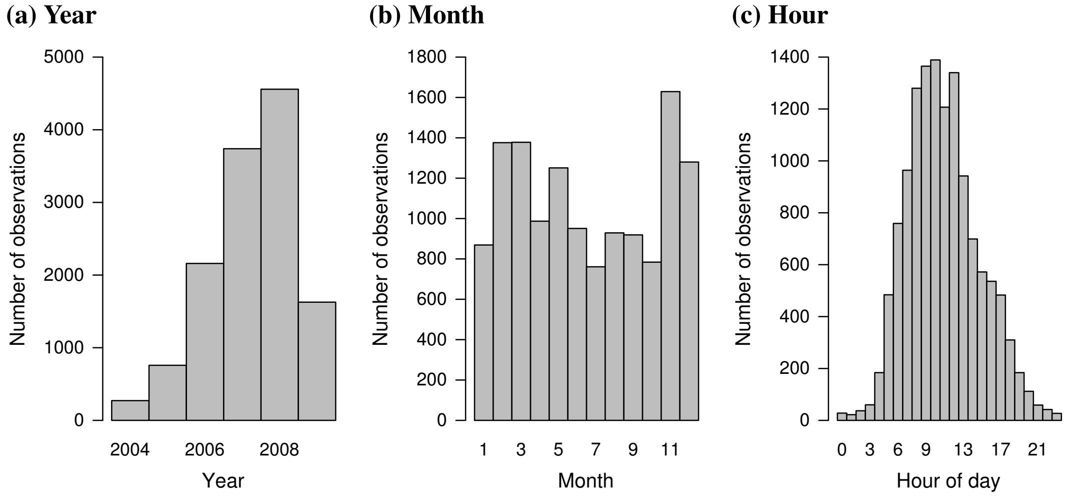


Figure 4: Distribution of seabird count observations across years, months, and throughout the day between January 2004 and June 2009.

The spatial distribution of count data depended on the fishing method, as different fisheries were concentrated in different areas within the EEZ (Figure 6). Observations in trawl fisheries were the most widely distributed, and dominated observations on the Stewart-Snares shelf, around Auckland Islands, Campbell Rise, Chatham Rise, and west of New Zealand. Most of the observations on Pukaki Rise and in Hauraki Gulf were made on bottom-longline vessels, whereas the majority of observations from the northeast and southwest of New Zealand were from surface longline fishing. Observations in set-net fisheries were predominantly from inshore areas, i.e., along North Island's west coast, South Island's southern coast, and around Kaikoura. The few observations conducted on purse-seine vessels were restricted to coastal North Island waters, largely in the northeast and Bay of Plenty.

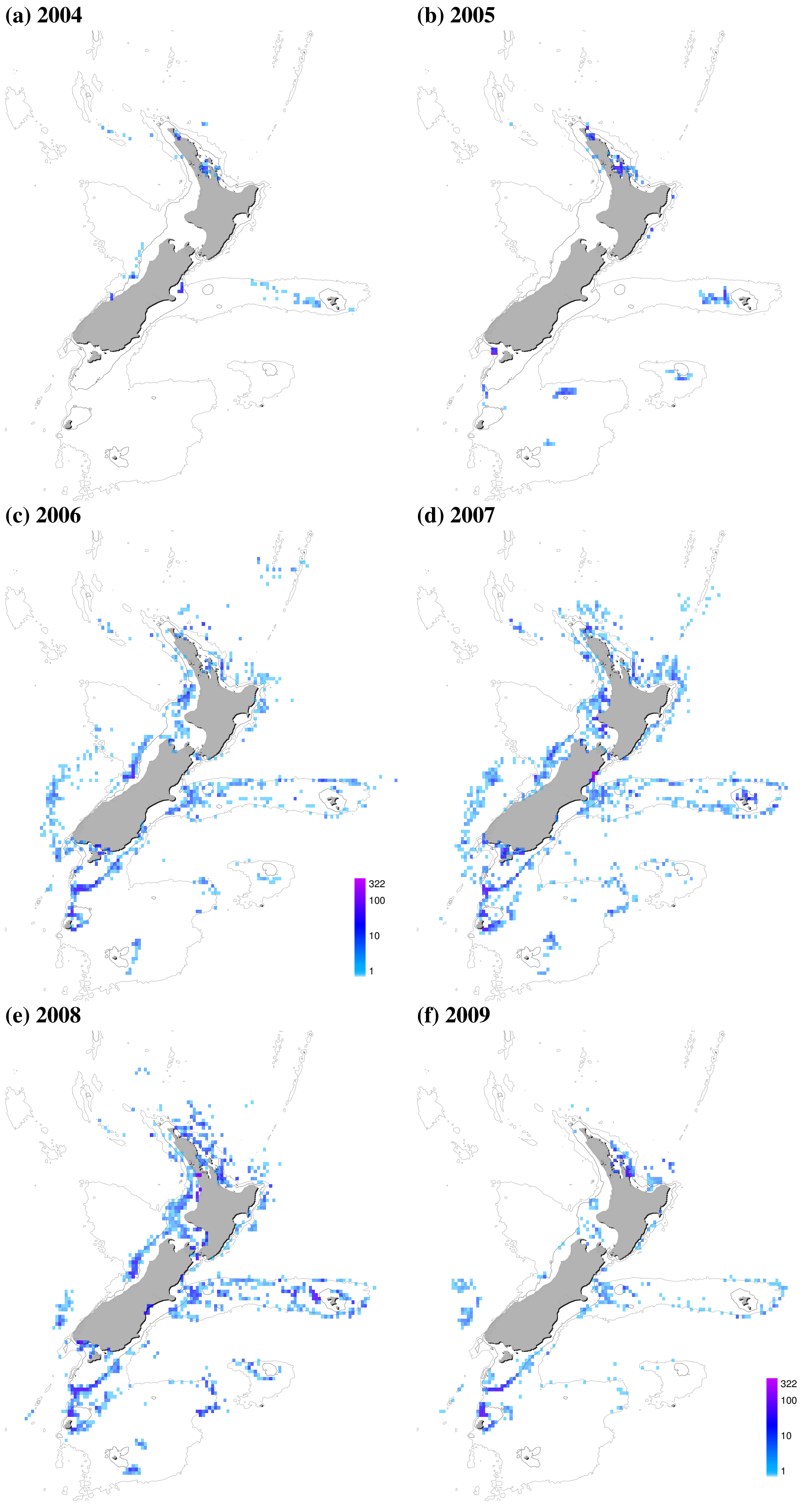


Figure 5: Annual distribution of seabird count observations by observers on-board commercial fishing vessels within New Zealand's Exclusive Economic Zone between January 2004 and June 2009. The colours indicate the number of seabird count observations within each 0.2 degree cell.

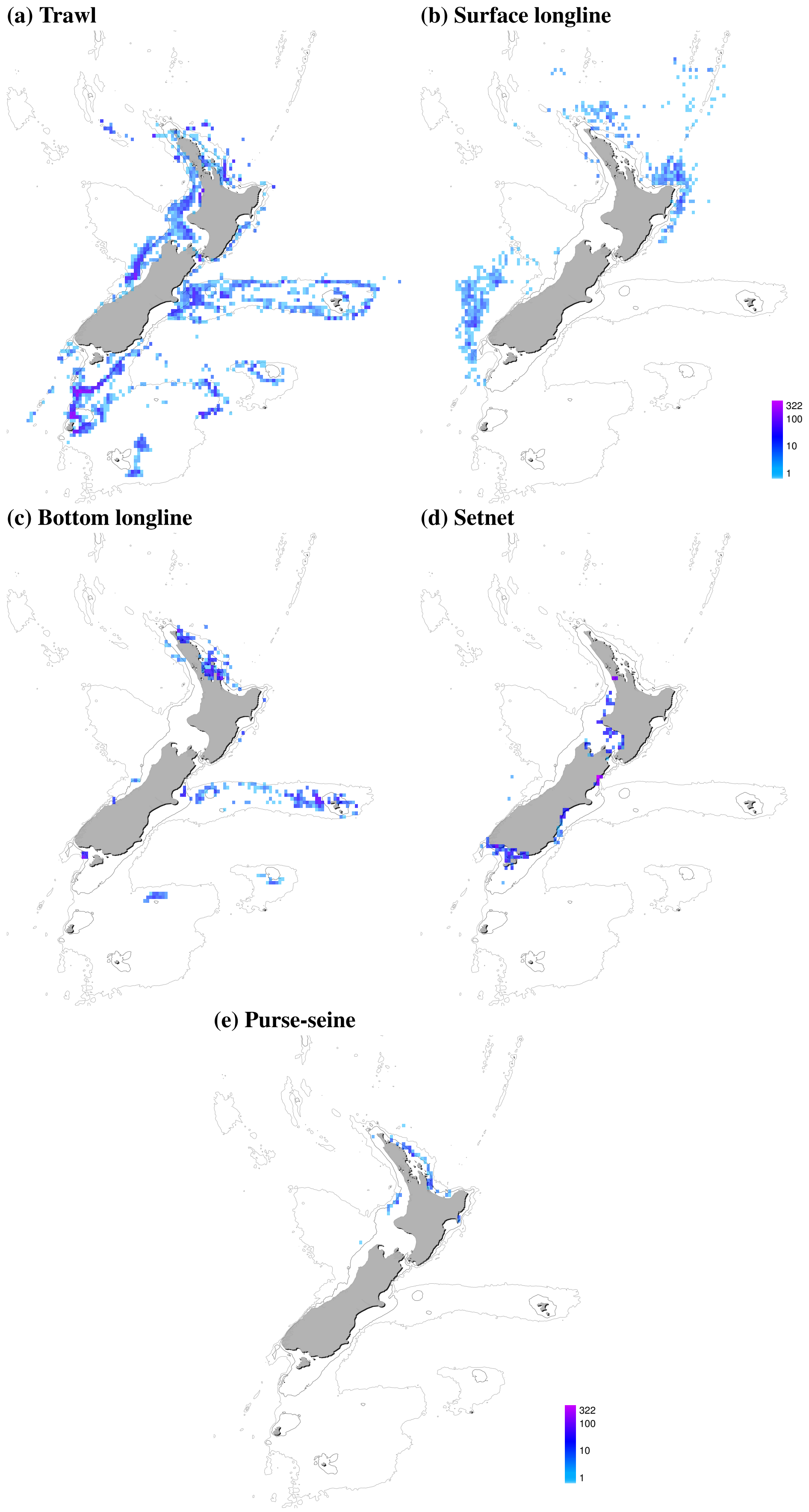


Figure 6: Distribution of seabird count observations by observers on-board commercial fishing vessels within New Zealand's Exclusive Economic Zone for different fisheries between January 2004 and June 2009. Data were binned to 0.2 degrees to meet Ministry for Primary Industries data confidentiality requirements.

Table 5: Number of seabird count observations by year, season, and fishing method between January 2004 and June 2009. BLL: bottom longline; SLL: surface longline; SN: set net; PS: purse seine.

Year	Season	Trawl	BLL	SLL	SN	PS	Unknown	Total
2004	Summer						21	21
	Autumn		114					114
	Winter	16	52					68
	Spring	19	50					69
2005	Summer		180					180
	Autumn		145					145
	Winter	16	134					150
	Spring	29	253	1				283
2006	Summer	438	51	13	76		149	727
	Autumn	254	9	196	17		17	493
	Winter	410		46			3	459
	Spring	383		34	62		2	481
2007	Summer	583		45	87			715
	Autumn	402	5	209				616
	Winter	459	81	153				693
	Spring	530	103		1075		7	1715
2008	Summer	568	1	72	440	46	55	1182
	Autumn	618	205	131			38	992
	Winter	699	388	94		24	34	1239
	Spring	781	42		266	45	11	1145
2009	Summer	595	121	12		65	5	798
	Autumn	366	176	149			138	829
	Total	7166	2110	1155	2023	180	480	13114

3.2 Data summary - seabird count data

A total of 81 codes was used to define species or species groups in the proximity of fishing vessels, based on 66 543 bird counts (Table 6). Cape petrels *Daption capense ssp.* was the most frequently recorded species with 8489 counts, followed by New Zealand white-capped albatross *Thalassarche cauta steadi* and the species group giant petrels (*Macronectes* spp.; >5000 counts). Also frequently recorded were southern Buller's albatross *Thalassarche bulleri bulleri*, and the grouping black-browed albatrosses (*Thalassarche melanophris* and *Thalassarche impavida*; each code >4000 counts). Four other species or species groups were also counted relatively frequently (>3000 times): white-chinned petrel *Procellaria aequinoctialis*, Salvin's albatross *Thalassarche salvini*, sooty shearwater *Puffinus griseus*, and great albatrosses (family Diomedeidae). All other species and species groups were counted infrequently and featured in less than 200 counts. Included in the bird counts were 854 zero records, when no seabirds were observed in the proximity of the fishing vessel.

The two most frequently encountered species also had the highest mean counts, with an average count of 63 Cape petrel and 33 New Zealand white-capped albatross per observation (Table 6). Also relatively common were Salvin's albatross (average 22 individuals), white-chinned petrel, sooty shearwater, southern Buller's albatross, albatrosses, and great albatrosses (average >10 individuals each). Most species and species groups had low abundances, with an average of less than 1 individual counted in the proximity of fishing vessels. These abundances reflect both abundance of the birds, and the spatial and seasonal distribution of the observations.

Distance data were included for 25 792 counts, and number of seabirds close to fishing vessels (i.e., within 100 m) were almost four times more numerous than those beyond 100 m distance (Table 6). With few exceptions, the prevalence of counts close to the vessel was consistent across species or species groups, with only five different codes counted more frequently beyond the 100-m boundary. These were generic codes, including seabird - small, seabird - large, smaller albatrosses, petrels, prions, and shearwaters, and *Procellaria* petrels. The same pattern was evident in the abundance data, with higher mean seabird abundances recorded close to the fishing vessel than at 100 m distance and beyond. The five records of seabirds that were at higher abundances further from the vessel had generic codes: seabird, seabird - small, seabird - large, albatrosses, and terns. This reflects the difficulty of identifying seabirds further than 100 m from the vessel.

A total of 79 observers provided seabird abundance data. The majority of observers conducted more than 100 observations, with an average of 211 observations per observer, involving 7 fishing trips (Figure 7). The maximum number of observations by an observer was 847. Observers distinguished up to 40 different species or species groups during observations, with most observers recording more than 20 different codes. On average, observers used 22 different codes for their counts of seabirds in the proximity of fishing vessels. The average number of seabirds recorded varied across observers, with few observers reporting more than 50 seabirds. One observer reported an average of close to 200 seabirds per observation.

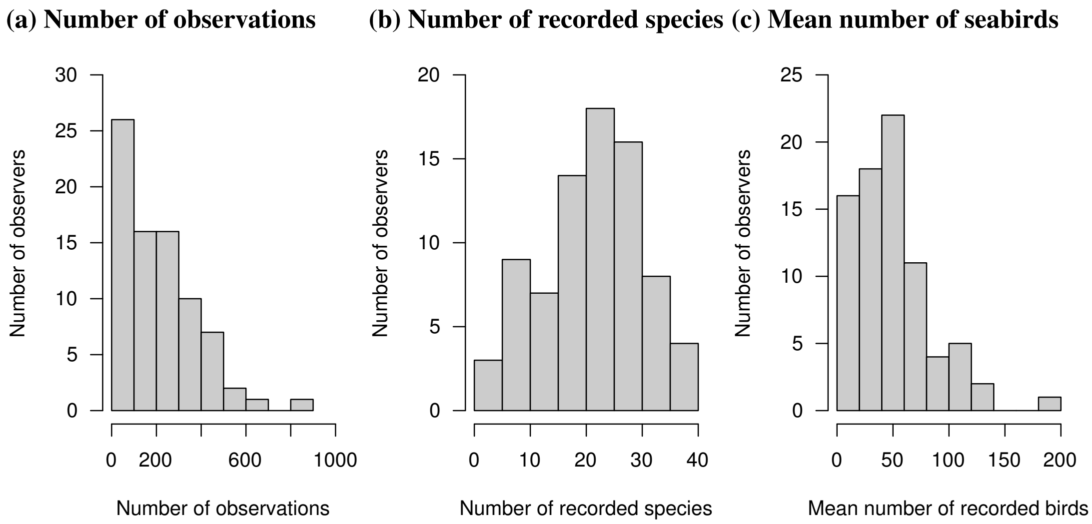


Figure 7: Number of observers and the number of seabird count observations (a), the number of seabird codes used during the observations (b) , and the mean number of seabirds recorded per observation (c) on-board commercial fishing vessels between January 2004 and June 2009.

There was a close relationship between the number of codes used and the number of observations carried out by observers, indicating an increase in the number of species and species groups with observer effort (Figure 8). About 20 species and species groups were common and recorded during the first 100 observations. As observer effort increased, there was an associated increase in the number of codes recorded, as less common seabird species were encountered. The number of new codes used reached a plateau at between 400–500 observations, and few new species were counted with the further increase in observer effort. The relationship between the number of codes used and the number of observations also indicated that the usage of codes among observers was relatively consistent. Although there was some variation, the curve-shaped spread of data points implied that count data were generally not biased by some observers who may have recorded more species than were present, or others who may have used few generic codes to reflect a variety of species encountered.

Table 6: Summary data of seabird abundance recorded by observers on-board commercial fishing vessels in New Zealand's Exclusive Economic Zone between January 2004 and June 2009. Abundance data from 2007 onwards were recorded by distance (close, far), defined by a 100-m distance threshold.

		Number of counts			Mean abundance		
Code	Code description	Total	Close	Far	Close	Far	All
XCP	Cape petrels	8489	2728	487	60.767	9.029	62.969
XWM	New Zealand white-capped albatross	5955	1721	397	32.881	3.916	32.912
XTP	Giant petrels	5415	1927	258	10.405	1.219	8.682
XBM	Southern Buller's albatross	5166	1611	313	16.950	2.520	16.768
XKM	Black-browed albatrosses	4534	1404	224	7.999	0.642	10.763
XGA	Great albatrosses	4302	407	108	1.664	0.552	5.026
XWC	White-chinned petrel	3855	1231	179	17.506	2.710	17.386
XSA	Salvin's albatross	3688	1267	134	19.433	1.686	22.098
XSH	Sooty shearwater	3644	1050	121	11.314	2.088	16.905
XAL	Albatrosses	3384	1610	994	13.187	25.386	15.261
XPE	Petrels	1708	775	275	5.386	4.141	6.581
XBG	Southern black-backed gull	1409	204	39	0.187	0.053	1.157
XGP	Grey petrel	1094	247	43	1.028	0.066	2.369
XRA	Southern royal albatross	1030	706	113	2.268	0.330	1.067
XBP	Black petrel	980	259	116	2.889	0.736	2.163
XPN	Prions	947	249	117	2.836	0.720	3.285
(None)	(None)	854	434	91	-	-	-
XSG	Seagulls	791	37	35	0.104	0.023	0.436
XCI	Chatham Island albatross	785	470	24	4.424	0.147	2.463
XWP	Westland petrel	769	57	4	0.295	0.010	0.803
XFS	Flesh-footed shearwater	753	256	72	2.046	0.302	1.931
XST	Storm petrels	753	283	62	2.195	0.687	3.729
XWA	Wandering albatrosses	702	260	59	0.479	0.055	0.380
XMA	Smaller albatrosses	699	169	359	2.751	1.076	2.319
XSY	Tasmanian albatross	678	114	23	2.605	0.142	5.139
XNP	Northern giant petrel	527	10	0	0.025	0.000	1.041
XSS	Seabird - small	335	47	216	0.151	4.641	1.913
XBS	Buller's shearwater	308	87	36	0.713	0.080	0.368
XCM	Campbell black-browed albatross	301	71	1	0.401	0.000	0.674
XSL	Seabird - large	245	31	151	0.057	2.622	1.141
XGM	Grey-headed albatross	232	100	12	0.405	0.088	0.471
XXP	Petrels, prions and shearwaters	209	87	102	2.551	1.665	1.608
XGF	Grey-faced petrel	208	87	49	0.477	0.222	0.346
XGT	Australasian gannet	203	47	14	0.030	0.009	0.087
XFT	Black-bellied storm petrel	184	83	19	0.477	0.350	0.418
XNR	Northern royal albatross	181	27	3	0.102	0.015	0.094
XLM	Light-mantled sooty albatross	138	12	8	0.015	0.002	0.028
XCC	Cape petrel	136	0	0	-	-	0.967
XSB	Seabird	100	23	19	0.140	0.249	0.199
XFP	Fairy prion	99	52	3	0.549	0.016	0.239
XDP	Common diving petrel	74	40	7	0.083	0.015	0.051
XFL	Fluttering shearwater	70	14	5	0.014	0.011	0.226
XPC	\emph{Procellaria} petrels	66	13	17	0.012	0.008	0.114
XNB	Northern Buller's albatross	65	1	0	0.001	0.000	0.106
XLA	Gulls and terns	57	48	0	0.071	0.000	0.034
XAS	Wandering albatross	55	2	0	0.000	0.000	0.025
XWF	White-faced storm petrels	49	28	0	0.156	0.000	0.089
XSP	Southern giant petrel	34	11	0	0.004	0.000	0.005
XPG	Penguins	33	3	0	0.001	0.000	0.007
THCA	White-capped albatrosses	31	0	0	-	-	0.207
SKUA	Skuas	30	16	1	0.004	0.000	0.003
XPB	Southern and northern Buller's albatrosses	18	18	0	0.058	0.000	0.022
XGB	Grey-backed storm petrel	14	0	0	-	-	0.004
XPM	Mid-sized petrels & shearwaters	14	11	1	0.818	0.041	0.324
CAAN	Southern skua	13	7	0	0.001	0.000	0.001
XSU	Boobies and gannets	13	1	1	0.000	0.000	0.001
XCA	Snares Cape petrel	11	0	0	-	-	0.005
XHG	Shags	10	0	1	0.000	0.000	0.001
PTMO	Soft-plumaged petrel	9	0	0	-	-	0.001
XTE	Terns	9	4	3	0.005	0.011	0.006
XSM	Southern black-browed albatross	7	0	1	0.000	0.000	0.002
XSR	White-fronted tern	7	1	0	0.003	0.000	0.079
STPA	Arctic skua	6	6	0	0.001	0.000	0.000
XAP	Antarctic petrel	6	0	0	-	-	0.009
XIY	Indian Ocean yellow-nosed albatross	6	0	0	-	-	0.000
XRB	Red-billed gull	6	1	0	0.000	0.000	0.001
XSW	Shearwaters	6	2	0	0.001	0.000	0.014
XPH	Hutton's shearwater	5	0	0	-	-	0.007
XPS	Pied shag	5	0	0	-	-	0.002
XWH	White-headed petrel	5	2	0	0.000	0.000	0.003
XAN	Antipodean albatross	3	0	0	-	-	0.001
PUAS	Little shearwater	2	1	0	0.000	0.000	0.001
SOOT	Sooty albatrosses	2	2	0	0.000	0.000	0.000
TUPH	Song thrush	2	1	0	0.000	0.000	0.000
XAF	Antarctic fulmar	2	0	0	-	-	0.000
XMP	Mottled petrel	2	0	0	-	-	0.001
XPP	Spotted shag	2	0	0	-	-	0.000
CYAT	Black swan	1	0	0	-	-	0.000
PTNE	Kermadec petrel	1	1	0	0.000	0.000	0.000
XLB	Little penguin	1	0	0	-	-	0.000
XTS	Short-tailed shearwater	1	1	0	0.000	0.000	0.000
	Total	66543	20475	5317	39.900	26.800	51.349

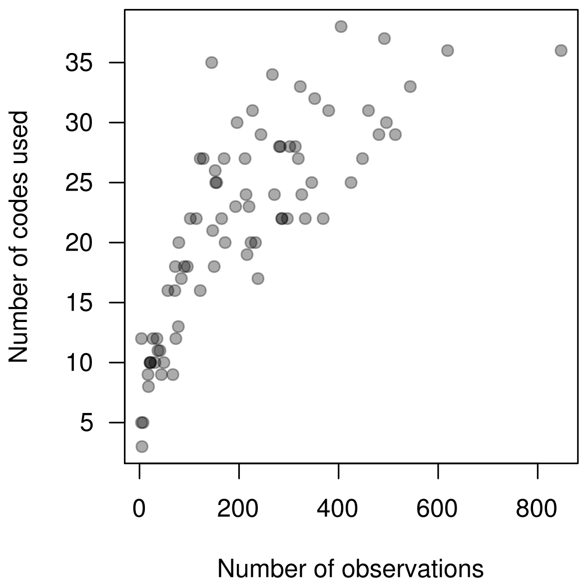


Figure 8: Number of observations versus number of codes used for species and species groups for seabird counts by observers on-board commercial fishing vessels in New Zealand waters between January 2004 and June 2009.

3.3 Exploratory analyses

3.3.1 Seabird abundance

Albatrosses and petrels were the two main species groups recorded in trawl, bottom-longline, and surface-longline fisheries, with some variation in the mean abundance of either species group across fisheries (Figure 9). Gulls and terns showed low mean abundances across all fisheries. Some of this variation may be related to the spatial distribution of different fishing methods, as the numbers and types of seabirds associated with vessels is greatly dependent on the overlap between their distribution and that of fishing operations. Observations involving set netting occurred predominantly inshore, where pelagic seabirds are generally scarce, whereas trawl effort was more widely distributed, including large off-shore areas, such as Chatham Rise and Campbell Plateau (see Figure 6), where albatrosses and petrels are abundant.

Across all observations, the mean number of seabirds ranged from 23 seabirds around set-net vessels to 406 seabirds around trawl vessels (Figure 9). With different fisheries concentrated in specific areas, the variation between fisheries will be partly due to the different number of seabirds in the different areas, and partly due to the different propensity of the different methods to attract seabirds.

The abundance of seabirds around fishing vessels did not vary greatly between setting and hauling (Figure 9), but were to be only slightly higher during hauling, especially in bottom-longline fisheries.

The mean number of seabirds in the proximity of commercial fishing vessels showed some fluctuation over the study period, with an overall increase in the number of seabirds recorded over time (Figure 10). From relatively low initial values in 2004 and 2005, the mean number of observed seabirds markedly increased in 2006, followed by a drop in 2007, and a subsequent increase since then. The change in the mean number reflects both a change in the fishing methods that were observed, with more seabirds associated with trawl fishing (Figure 9), and a change in the form, with the inclusion of a distance category from the 2007–08 fishing year (i.e., from 1 October 2007). Any analysis of trends that includes these early data must consider both the change in the fisheries that have been observed, and the change in the data collection.

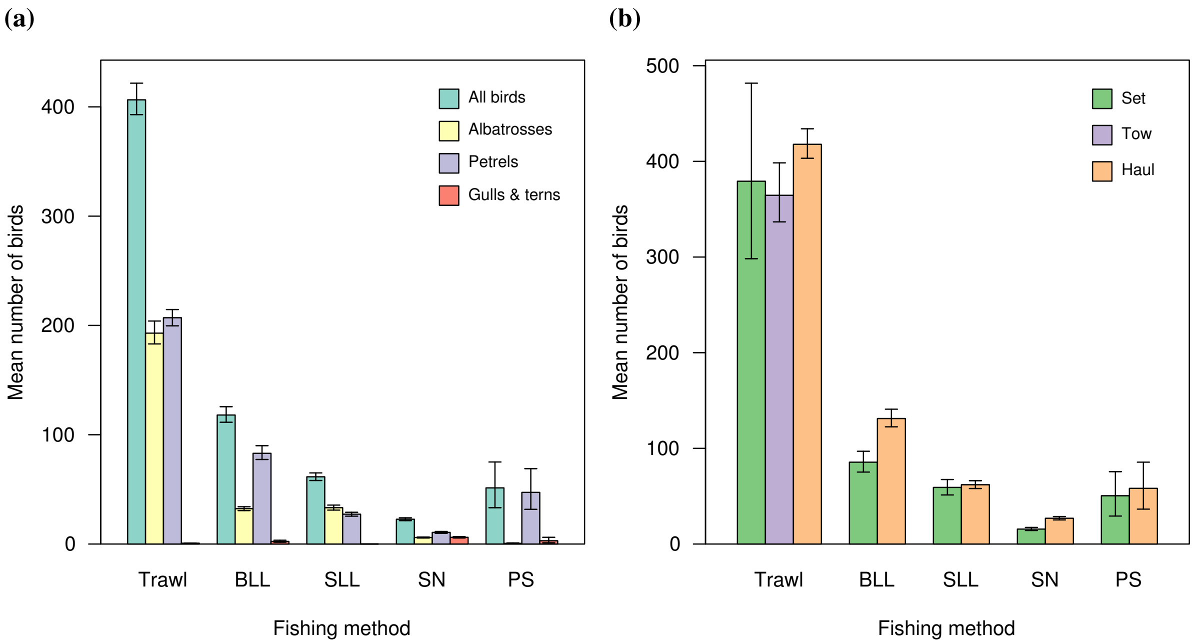


Figure 9: Mean number of seabirds observed in the proximity of commercial fishing vessels within New Zealand's Exclusive Economic Zone between January 2004 and June 2009 by fishing method (BLL: bottom longline; SLL: surface longline; SN: set net; PS: purse seine). Error bars indicate the 95% confidence interval around the means, obtained from 1000 bootstraps.

3.3.2 Seabird distribution

Observer-reported seabird count data revealed distinct patterns in the spatial distribution of the seabird genus that had the highest abundance within each 1-degree cell (Figure 11). In general, small albatrosses (*Thalassarche* spp., also called mollymawks) were the most abundant genus observed in the proximity of fishing vessels. This genus was the most abundant in inshore and offshore waters in the east and west of Chatham Rise, north of Auckland Islands, and along New Zealand's west coast. In contrast, shearwaters (*Puffinus* spp.) were the most abundant genus recorded in Hauraki Gulf. *Procellaria* petrels were the most abundant genus in the north of North Island, and also in some areas to the south of South Island and in subantarctic waters, due to the large number of white-chinned petrels (*Procellaria aequinoctialis*) breeding in that area. Giant petrels (*Macronectes* spp.) were locally dominant in southern waters. Great albatrosses (*Diomedea* spp.) were also locally dominant, in the north-west of North Island. Prions (*Pachyptila* spp.) were only dominant on the southern North Island west coast, while gulls (*Larus* spp.) were dominant only in inshore waters in North and South islands.

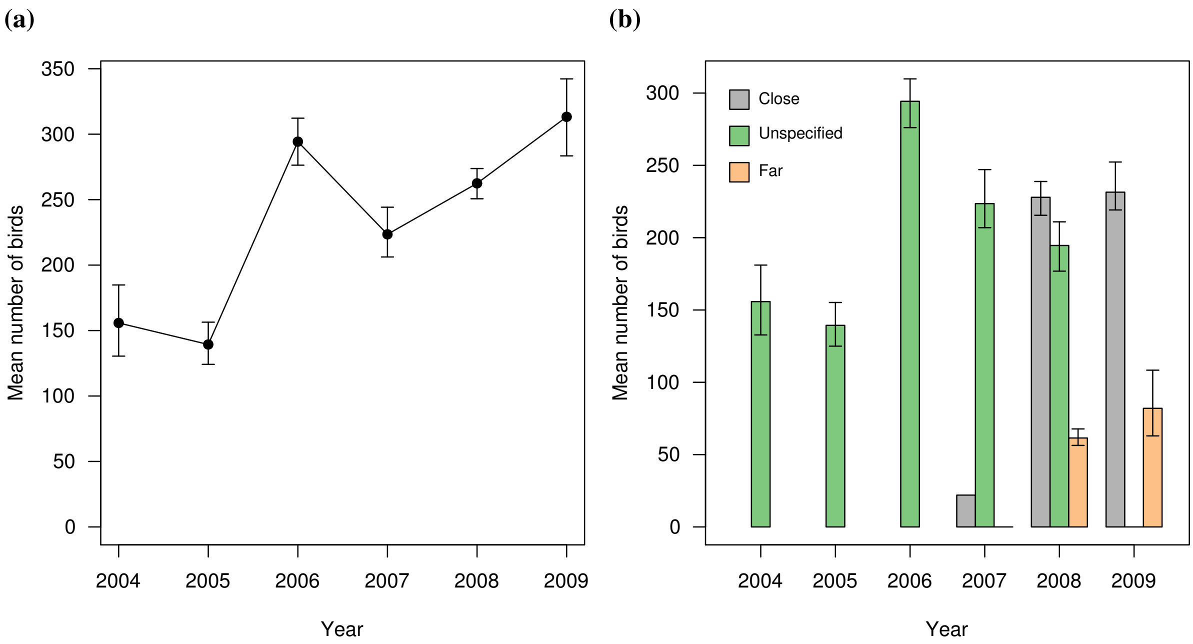


Figure 10: Mean number of seabirds observed in the proximity of commercial fishing vessels within New Zealand's Exclusive Economic Zone between January 2004 and June 2009. Overall abundance (a), and abundance in relation to distance from the vessel (b), as recorded from 1 October 2007 onwards. Error bars indicate the 95% confidence interval around the means, obtained from 1000 bootstrap samples.

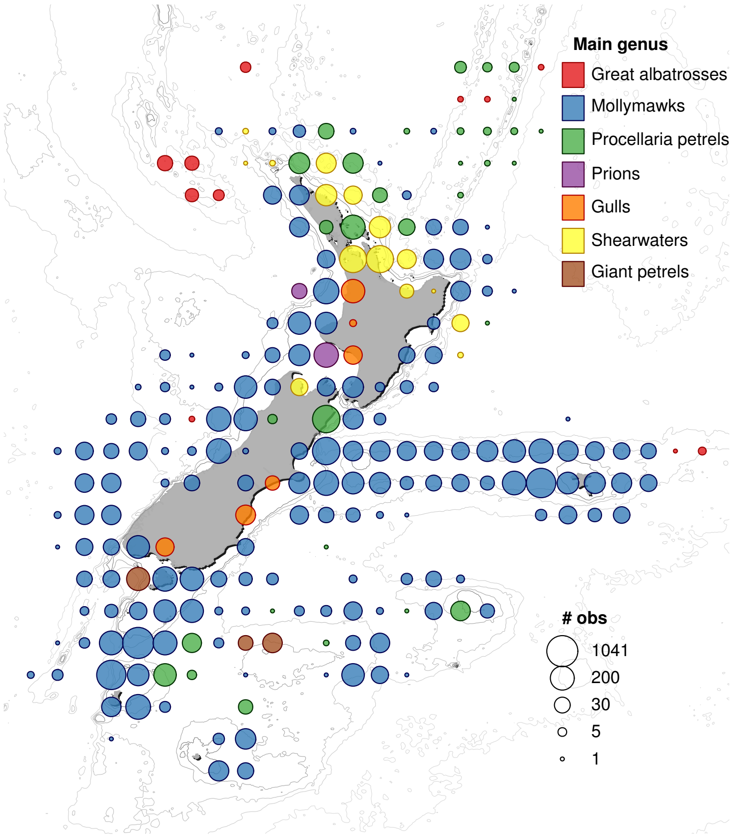


Figure 11: Most abundant seabird groups throughout New Zealand's Exclusive Economic Zone based on observer records between January 2004 and June 2009, as defined by the highest mean numbers counted around fishing vessels across observations. The observed species were grouped as great albatrosses, *Diomedea*; mollymawks, *Thalassarche*; prions, *Pachyptila*; gulls, *Larus*; shearwaters, *Puffinus*; giant petrels, *Macronectes*. Data were binned to 1 degree of latitude and longitude.

3.4 Comparison of observer data with other data sources

Comparing observer-reported distribution and abundance data with those from other data sources provides an indication of the accuracy of observer data. There was general agreement between observer data and other data sources for some species, such as flesh-footed shearwater *Puffinus carneipes*, whereas for other species, such as black petrel *Procellaria parkinsoni*, there were notable discrepancies (Figure 12). The seabird count data indicate that the flesh-footed shearwater are predominantly in North Island waters, with occasional records from northern South Island, Chatham Rise and south of Stewart Island. This distribution agrees with other data sources, including NABIS, with flesh-footed shearwater regularly reported off Kaikoura (see e.g., http://www.oceanwings.co.nz), and records extending south to Foveaux Strait, and eastwards to Chatham Islands (Marchant & Higgins 1990, Robertson et al. 2003). For black petrel, the spatial distribution indicated by observer count data does not match the NABIS distribution. Both data sources indicate the presence of black petrel in Hauraki Gulf and other North Island regions, and at the top of South Island. In contrast to NABIS, however, observer data also suggest that this species occurs on the South Island west coast, along Chatham Rise, and further south around Auckland, Bounty, and Antipodes islands. For black petrel, it is likely that the southern observer counts were of related Westland or white-chinned petrels, based on the known distribution and breeding locations of these two petrel specie.

In addition to data on the spatial distribution of seabirds, observer counts provide information about seabird abundance over time. Many seabird species are migratory, and their distribution and abundance change considerably across seasons, generally in relation to breeding cycles (e.g. Shaffer et al. 2006, Burger & Shaffer 2008). Sooty shearwater, for example, breed between September and May on islands around New Zealand (Taylor 2000b), so that this species is abundant in New Zealand waters during this time. Following the breeding season, sooty shearwaters migrate to the North Pacific Ocean, and are relatively scarce in New Zealand over winter, before returning for the next breeding season in September (Shaffer et al. 2006). The seasonality in sooty shearwater abundance was evident in the seabird count data, with the highest number of sooty shearwater observed around fishing vessels in March and April, and no or few records between June and September (Figure 13). Furthermore, observer data clearly indicate a bimodal abundance pattern over the breeding season, with a drop in sooty shearwater numbers in December and January, followed by a second, smaller peak in October/November. This bimodal pattern was also evident in bycatch data of sooty shearwater in New Zealand trawl fisheries (Figure 13). The capture rate of sooty shearwater modelled from observed captures (Abraham & Thompson 2011) showed a similar seasonal variation to that in the abundance data. The low numbers of sooty shearwater observed in December and January could be related to adults intensively feeding their chicks and foraging close to their colonies.

3.5 Seabird identifications

Identification of seabirds at the species (or sub-species) level may be difficult at sea, i.e., for types of seabirds that are difficult to distinguish. For example, white-chinned petrel *Procellaria aequinoctialis*, black petrel *Procellaria parkinsoni*, and Westland petrel *Procellaria westlandica* are similar-looking, dark, medium-sized petrel species. Observers receive training in species identification, but experience and identification skills vary among observers. In some cases, data are from observers who are making their first trip at sea, and so who have little experience of seabird identification.

Comparisons between observer and post-mortem identifications of incidentally captured seabirds highlight inaccuracies in at-sea seabird identifications, even when observers are able to handle seabirds (Table 7). For some species, at-sea identifications were confirmed by subsequent post-mortem necropsy, whereas mis-identifications were detected for other records, such as that of four sooty shearwaters that

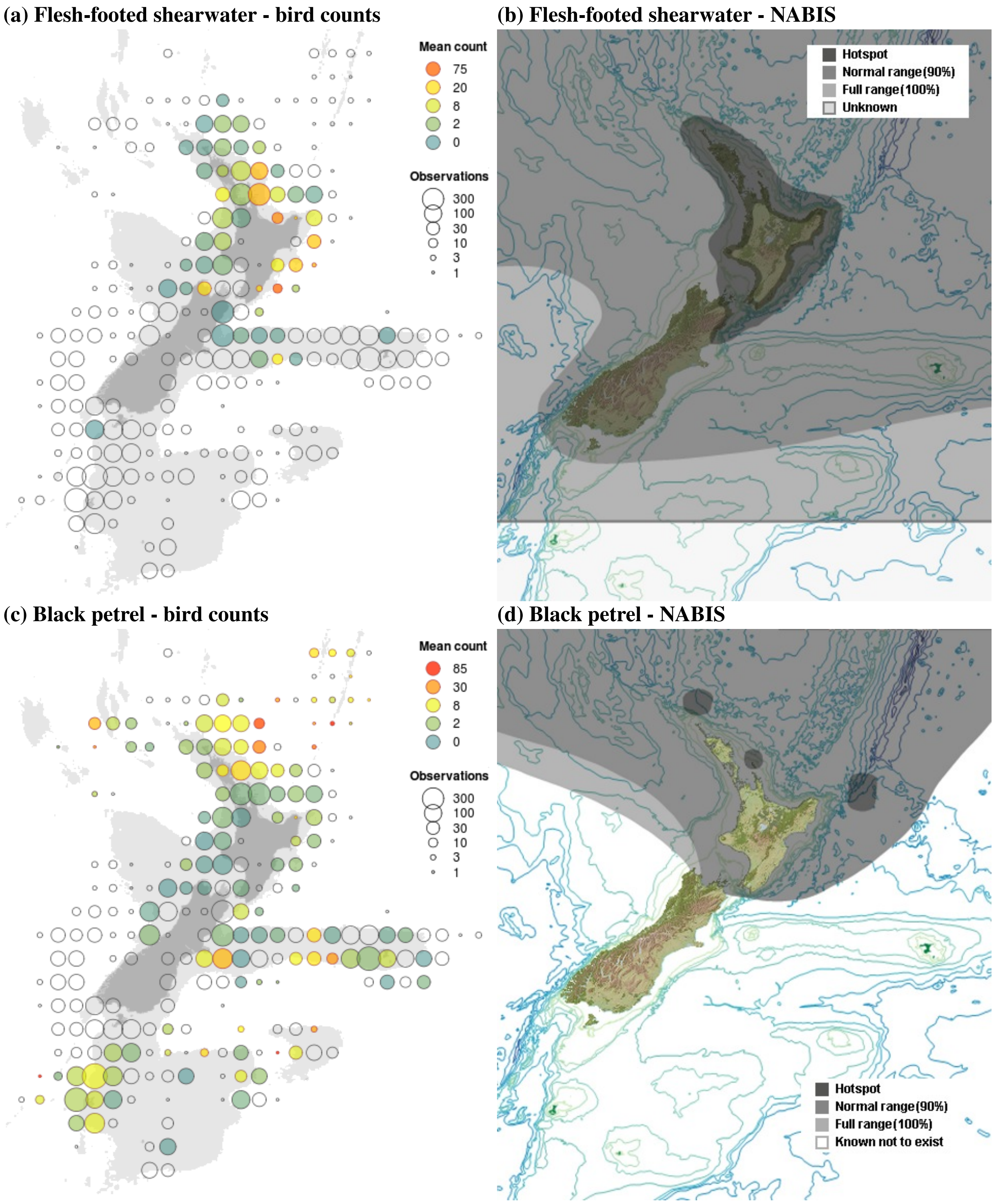


Figure 12: Spatial distribution of flesh-footed shearwater *Puffinus carneipes* (a, b) and black petrel *Procellaria parkinsoni* (c, d) based on observer counts conducted on-board commercial fishing vessels (c, d) and on National Aquatic Biodiversity Information System (NABIS, http://www.nabis.govt.nz) distribution maps (b, d). In a, c the colours indicate the mean count within 1-degree cells. The size of the circles is related to the number of observations. Empty circles indicate that there were no records of the corresponding seabird within that 1-degree cell.

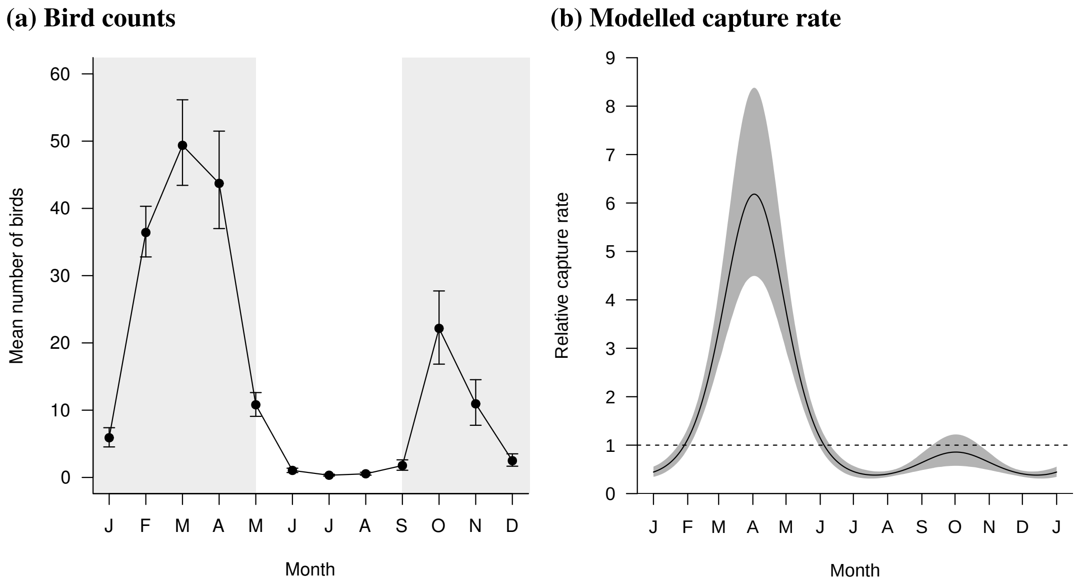


Figure 13: Number of sooty shearwaters *Puffinus griseus* observed in the proximity of commercial fishing vessels (a), and the capture rate of this species in trawl fisheries modelled from observed captures (b)(from Abraham & Thompson (2011). Data in (a) were collected by observers between January 2004 and June 2009, with error bars indicating the 95% confidence interval obtained by bootstrapping, and the shaded area indicating the species' breeding period. Data in (b) were collected by observers between October 2002 and September 2009, with the shaded area indicating the 95% confidence interval around the mean (black line).

had been mis-identified as white-chinned petrels.

The correct identification of seabirds by observers is further hampered by changes in taxonomy, i.e., when the corresponding coding and observer training do not keep up-to-date. Recent taxonomic changes have included the splitting of one species into separate species, with the original species code retained for one of the newly added species. For the records concerned, it is unclear whether the original code describes the group of similar species or the newly split species. Furthermore, observers that were trained before the taxonomic changes took effect may continue to use the codes as in their original designation. An example of this kind of taxonomic change is the species shy albatross (previously known as *Diomedea cauta*) that was split into Tasmanian albatross (*Thalassarche cauta cauta*), New Zealand white-capped albatross (*Thalassarche cauta steadi*), Salvin's albatross (*Thalassarche salvini*), and Chatham Island albatross (*Thalassarche eremita*), involving the move of all of these species into the genus *Thalassarche* (Robertson & Gales 1998). Some observers routinely use the code 'XSY' to indicate New Zealand white-capped albatross, whereas it is now strictly reserved for the Tasmanian albatross.

Mis-identifications and uncertainty surrounding the assigning of codes to some species or species groups make the unambiguous interpretation of the count data difficult. In order to make better use of these data, a method needs to be developed that allows for outlying observations to be detected and potentially discarded.

Table 7: Comparison of identifications recorded by observers on-board commercial fishing vessels and subsequent post-mortem identifications of seabirds observed caught in fisheries between January 2004 and June 2009 in New Zealand waters (data courtesy of D. Thompson, NIWA).

Observers' identification		Post-mortem identification			
Code	Common name	Code	Common name	# seabirds	Prop. (%)
XSH	Sooty shearwater	XSH	Sooty shearwater	200	96
		XFS	Flesh-footed shearwater	5	2
		XWC	White-chinned petrel	1	0
		XBP	Black petrel	1	0
		XWM	New Zealand white-capped albatross	1	0
XWC	White-chinned petrel	XWC	White-chinned petrel	106	95
		XSH	Sooty shearwater	4	4
		XWP	Westland petrel	1	1
		XWM	New Zealand white-capped albatross	1	1
XWM	New Zealand white-capped albatross	XWM	New Zealand white-capped albatross	105	97
		XAL	Albatrosses	2	2
		XSH	Sooty shearwater	1	1
XPE	Fulmars, petrels, prions and shearwaters	XWC	White-chinned petrel	22	63
		XGF	Grey-faced petrel	6	17
		XSH	Sooty shearwater	5	14
		XGP	Grey petrel	1	3
		XBP	Black petrel	1	3
XBM	Southern Buller's albatross	XBM	Southern Buller's albatross	30	97
		XWM	New Zealand white-capped albatross	1	3
XSA	Salvin's albatross	XSA	Salvin's albatross	25	93
		XWM	New Zealand white-capped albatross	2	7
XBP	Black petrel	XBP	Black petrel	11	52
		XSH	Sooty shearwater	6	29
		XWC	White-chinned petrel	3	14
		XFS	Flesh-footed shearwater	1	5
XSY	Tasmanian albatross	XWM	New Zealand white-capped albatross	20	100
XCI	Chatham Island albatross	XCI	Chatham Island albatross	11	100
XXP	Petrels, prions and shearwaters	XWC	White-chinned petrel	9	90
		XWF	New Zealand white-faced storm petrel	1	10
XGP	Grey petrel	XGP	Grey petrel	8	100
XAL	Albatrosses	XWM	New Zealand white-capped albatross	5	71
		XAL	Albatrosses	2	29
XKM	Black-browed albatrosses	XCM	Campbell black-browed albatross	4	100
XRA	Southern royal albatross	XWM	New Zealand white-capped albatross	2	67
		XRA	Southern royal albatross	1	33
XMA	Smaller albatrosses	XWM	New Zealand white-capped albatross	3	100
XFS	Flesh-footed shearwater	XFS	Flesh-footed shearwater	3	100
XDP	Common diving petrel	XDP	Common diving petrel	2	67
		XPR	Antarctic prion	1	33
XCP	Cape petrels	XCC	Cape petrel	3	100
XTP	Giant petrels	XNP	Northern giant petrel	1	50
		XSP	Southern giant petrel	1	50
XGM	Grey-headed albatross	XBM	Southern Buller's albatross	1	50
		XSA	Salvin's albatross	1	50
XWP	Westland petrel	XWP	Westland petrel	1	100
XWA	Wandering albatrosses	XAU	Gibson's albatross	1	100
XSL	Seabird - large	XIY	Indian Ocean yellow-nosed albatross	1	100
XSB	Seabird	XGP	Grey petrel	1	100
XPN	Prions	XFP	Fairy prion	1	100
XGA	Great albatrosses	XWM	New Zealand white-capped albatross	1	100
XFT	Black-bellied storm petrel	XFT	Black-bellied storm petrel	1	100
XFP	Fairy prion	XFP	Fairy prion	1	100

4. DISCUSSION

The most common technique used to collect data about seabird distributions at sea has been the use of remote tracking devices, with few studies providing information of seabird interactions with fisheries (but see for example Petersen et al. (2008), Jiménez et al. (2011), Torres et al. (2011)). In the context of bycatch management and reduction, accurate information on seabird distributions, the number of seabirds around fishing vessels, and on seabird interactions with fisheries is crucial to determine the risk of seabirds getting captured or injured.

Counts of seabirds conducted by observers on-board fishing vessels represent an efficient method to gather valuable information on at-sea seabird distributions and on seabird interactions with fisheries. Counts are quick to carry out, do not need additional observers than those already on-board vessels, and potentially ensure the monitoring of species that are difficult to study using other methods, such as remote tracking. There are, however, limitations to the seabird count data that need to be considered when analysing the data.

Experience and identification skills vary among observers, potentially resulting in inconsistencies in the count data. Mistakes in species identifications limit the value of seabird count data, and observers have been increasingly encouraged to use generic codes when they are unsure about identifications at the species level. Increasing use of generic codes means that the number of mis-identifications is expected to decrease over time. However, count data recorded with generic codes are less informative than those recorded with species codes. To ensure the collection of high-quality data, observer training needs to be sufficient to enable them to confidently distinguish seabirds at the species level. In subsequent analysis, an assessment of observer skill could be made by comparing the consistency of the recorded species between observers. In some cases, there are two observers on board, and the name of the observer carrying out the seabird count is not recorded. Recording identity of the observer who carried out each observation would help with identifying observer skill.

Other data limitations relate to differences across years, as observations during which seabird counts were carried out were not always representative of fishing effort. For example, the low number of observations in 2004 and 2005 were mostly conducted in bottom-longline fisheries, with other fisheries greatly under-represented. As different fisheries are concentrated in different areas of New Zealand's EEZ, differences in the counts of seabirds around fishing vessels may represent spatial differences in seabird communities and abundances instead of differences over time. In addition to variations in fishing practices and observer coverage, inter-annual variation in seabird count data may be due to changes in the data-recording method. Count data from 2007 onwards were recorded with the distance at which seabirds were observed (within or beyond 100 m of the vessel). The inclusion of a distance category may have led observers to include a higher number of seabirds in their counts, as they were explicitly requested to also include seabirds not in the immediate vicinity of fishing vessels. Some observations since the introduction of distance-dependent records only present counts of seabirds close to the vessel. In the present study, these records were assumed to indicate that there were no seabirds in the distant category, but it is possible that observers did not consistently search for seabirds beyond 100 m from the vessel. False absences, i.e., when a species is recorded as absent when it is present, may bias models of species distribution (Reese et al. 2005). Observers should be instructed to clearly indicate zero counts.

With the collection of count data currently continuing, the use of increasingly consistent protocols may allow detailed analysis of potential trends in seabird abundance in the future. As count data have potential to improve current models of seabird captures in fisheries by relating the number of observed captures to the number of seabirds present around fishing vessels, high-quality abundance data would enable more accurate bycatch and risk assessments.

In the present study, missing information on count forms was obtained from fishing-effort forms, based on the trip and fishing event numbers. To be able to complement data this way, it is important that observers record the correct trip and fishing event numbers on the forms.

Recommendations for future data collection also include the recording by observers of fishing waste discharge at the time of seabird counts. As the abundance of seabirds around fishing vessels is strongly dependent on the management of fishing waste, offal and discards (Abraham et al. 2009, Abraham 2010), obtaining this information would allow greater understanding of the attraction of seabirds to vessels.

5. Acknowledgments

We are particularly grateful to the fisheries observers for their ongoing collection of these data. This project was funded by the Department of Conservation Conservation Services Programme (CSP) through a grant of funds in June 2008. Copies of the completed forms were supplied by CSP, and additional data on fishing times and locations were obtained from the Ministry for Primary Industries. We especially wish to thank Igor Debski and Kris Ramm of CSP for their assistance with this project.

We also appreciate comments from members of the CSP Technical Advisory Group on preliminary analyses of these data.

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